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Urban electricity governance and the (re) production of heterogeneous electricity constellations in Dar es Salaam

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Abstract

Background Electricity infrastructures in sub-Saharan African cities are characterized by heterogeneous socio-technical constellations, including alternative grid access channels and off-grid systems. These constellations secure access beyond conventional grids but also produce adverse social, environmental, and economic outcomes affecting sustainable energy transition efforts. In fact, interventions aiming to promote energy transitions may be restricted by institutional mechanisms that produce and maintain these heterogeneous constellations. This article explores these institutional mechanisms by focusing on the governance of heterogeneous electricity constellations in Dar es Salaam, Tanzania. It develops a novel framework on governance modalities to understand and explain the logics, mechanisms, and actors that govern different constellations across diverse neighborhoods as well as to unpack how they limit the potential of sustainable energy transitions and offer specific opportunities for them.

Results This article is based on a qualitative case study covering three diverse neighborhood types in Dar es Salaam (i.e., low-income, peri-urban, and affluent areas) that reflect heterogeneous user demands. The research draws on interviews with residents and community leaders to understand local modes of coordination, the participatory observation of technical features and user practices, as well as document sources and semi-structured expert interviews to analyze institutional aspects. Our study demonstrates that heterogeneous electricity constellations in Dar es Salaam are governed by the place-based interplay of four governance modalities: hierarchical, market-based, network-based, and managerial governance. Based on this conceptualization, we identified critical barriers for interventions toward urban energy transitions in the context of infrastructural heterogeneity, namely, conflicting logics that shape conventional grid services, complex and fragmented actor constellations, and diverging, place-based interests among various actors, including different state actors.

Conclusions Our study indicates that heterogeneous urban infrastructure constellations are not merely a response to the considerable socio-spatial inequalities within Southern cities. Rather, their prevailing importance and (re)production must be understood as resulting from the interplay of various governance modalities. The study contributes to debates on urban energy transitions in sub-Saharan Africa by explaining the institutional complexity associated with infrastructural heterogeneity, which can restrict interventions aiming to improve and universalize service provision through heterogeneous urban electricity constellations.

Keywords Urban electricity governance, Urban energy transition, Governance modalities, Electricity constellations, Infrastructural heterogeneity, Tanzania, Global South

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Background

Urban infrastructure scholars have argued that the multiplicity of technologies, actors, and of the ways to provide and use electricity contributes significantly to the functioning of Southern cities. This socio-technical heterogeneity, it is argued, responds to user demands that are unmet by conventional, centralized grids [1, 2]. Recent intra-urban comparative studies on electricity services in different African cities have demonstrated that socio-technical alternatives equally serve low-income users, the middle classes, and urban elites [3]. Such heterogeneous electricity constellations thus offer a suitable starting point to think through urban energy transitions, i.e., how electricity systems co-evolve with diverse urban developments [4]. Earlier studies have pointed to sustainability challenges associated with socio-technical alternatives that are primarily provided through unregulated markets, including equity and solidarity [4, 5] and negative environmental externalities (e.g., emissions of air pollutants, greenhouse gases and noise, inefficient resource use). These sustainability challenges underline an urgent need to govern heterogeneous infrastructures more effectively. However, urban energy transition efforts aiming to address the environmental externalities and social inequalities caused by heterogeneous infrastructures [6], face considerable challenges related to various governance aspects favoring the status quo. Scholarship on urban electricity governance has frequently emphasized how intertwined institutional mechanisms and service provision logics constrain public policy interventions trying to improve grid electricity access, such as innovations aimed at increasing revenue collection or regularizing services in low-income neighborhoods [7–9]. However, this scholarship does not sufficiently reflect on the high degree of urban diversity and infrastructural heterogeneity in cities in sub-Saharan Africa—leaving a critical gap in understanding how heterogeneity shapes the potential for sustainable energy transitions.

Urban diversity and infrastructural heterogeneity often go together with highly complex actor constellations which can sustain or restrict sustainability interventions (e.g., regulations). Such constellations include not only formally mandated actors such as governments, utility companies, and regulatory authorities whose primary focus lies on conventional grid governance. Instead, private users, neighborhood initiatives, and landlords co-shape the provision and use of conventional grids in cities in sub-Saharan Africa as well as alternative ways to access these grids and off-grid alternatives [e.g., 10, 11]. Particularly in low-income settlements, the everyday practices of diverse actors without official mandates are crucial for the governance of electricity services [12]. However, beyond such settlement contexts, the mechanisms

through which powerful actor interests shape electricity constellations differently *across* neighborhoods have hardly been addressed (as an exception, see Silver's [13] study on premium access for industrial users). Thus, governance perspectives need to better account for the breadth of service provision logics and institutional mechanisms that exist, including the rules and interactions at play as well as whose interests and ideals are conveyed through different institutions.

In sub-Saharan Africa, strong (local) government-led coalitions that can effectively initiate urban infrastructural interventions are rather an exception [14]. Often, the ineffectiveness of hierarchical decision-making capabilities coincides with multiple, co-existing local governance modalities [15], characterized by numerous actors “drawing upon different normative registers and sources of legitimacy and authority” [16: 5]. This pluralism of actors also questions the presumed dominance of state actors (national, regional, and local governments, bureaucrats, state planners, regulators) and state-owned companies in governing (urban) electricity infrastructures, who themselves often operate beyond state regulations. Yet, state actors still vitally shape urban infrastructures governance through ‘everyday’ practices and interactions with users and providers [17], equally relying on “structural forms and practices of power” [18: 232] (e.g., formal mandates and coercion strategies) and more diffuse expressions of power. State actors thereby apply ‘practical norms’, i.e., implicit yet routinized practices that complement, bypass, or contradict formal institutions [19]. Consequently, research on the governance of existing heterogeneous electricity constellations needs to more adequately address (1) the institutional complexity resulting from the interplay of different governance modalities, beyond a predominant focus on market-based logics that govern alternative services, such as solar systems and generators [20], and (2) the important role various state actors have beyond frequent attempts to regularize alternative services [14]. The research question resulting from these gaps is: “How does the interplay of different governance modalities explain the emergence and persistence of urban and infrastructural heterogeneity in sub-Saharan African cities?”

Primarily actor-centric governance perspectives often applied at the national level [e.g., 21] seem impractical to capture the institutional complexity and the associated temporal and spatial fluidity of actor arrangements, while at the same time providing suitable analytical categories. Furthermore, these actor arrangements influence urban infrastructure governance beyond their current actions, interests, and policies. Rather, they also shape institutional mechanisms which have co-evolved in interaction with such actor

features and which are characterized by relatively high permanence. This paper thus uses an institutions-centered perspective to explore how the interplay of different governance modalities shapes socio-technical heterogeneity and hence the potential for interventions promoting urban energy transitions. We develop a framework using governance modalities as analytical lenses highlighting how institutions—comprised of rules, norms, and decision-making logics—explain policy outcomes [22, 23]. Based on earlier literature [e.g., 24, 25], our framework comprises four governance modalities: hierarchical, market-based, network-based, and managerial. Understanding urban electricity governance through these modalities is necessary to explain how socio-technical heterogeneity emerges and persists, but can also be changed.

We apply this framework to a case study in Dar es Salaam, Tanzania, where rapid and unequal growth patterns challenge traditional infrastructure planning and management [26]. Planning and management are characterized by the Tanzanian government's hierarchical approach toward providing universal, grid-based electricity [27], a goal that remains unreachable in the short term. The conventional grid, however, fails to address the heterogeneous electricity service demands across different neighborhood settings, namely: (a) affordability in low-income settlements and sufficient reliability in middle-income areas; (b) timely grid connectivity in peri-urban settlements; and (c) premium reliability in affluent residential, commercial, and industrial areas. We analyze how governance modalities and their interplay produce these limitations, and, thus, the persistent heterogeneity of electricity constellations. Furthermore, we explain how different service provision logics, actor involvement, and interests maintain the functioning of such constellations. This institutional perspective, therefore, enables a better understanding of the implications for urban energy transitions.

The remainder of the paper is structured as follows: first, we conceptualize urban electricity governance in the context of sub-Saharan African cities' urban and infrastructural heterogeneity which in turn led to the development of our governance modalities framework. We then outline the study methods. In our results section, we introduce the empirical context before using the governance modalities to analyze how they shape heterogeneous electricity constellations across three different urban settings in Dar es Salaam. Our discussion then highlights three critical insights on how institutions shape and affect the (re)production of heterogeneous electricity constellations and the promotion of urban energy transitions. Finally, we conclude by relating our results to earlier calls for better governing heterogeneity.

Theory and analytical framework

Mayntz and Scharpf's [22] 'actor-centered institutionalism' is one analytical approach that uses so-called "modalities of social coordination" as institutional categories to explain policy outcomes [28: 172]. The approach understands institutions as a restricting or enabling framework for actors' (inter)action and decision-making. At the same time, actors possess agency to pursue their interests, and thus continuously shape institutions. Modalities as analytical categories represent ideal types, which in reality are mutually dependent and overlapping, making it "important to appreciate how they 'work through one another'" [23: 411]. Governance modalities can provide a useful analytical lens to capture how governance shapes electricity constellations differently across diverse urban settings—and thus illustrate the complex, geographically differentiated institutional contexts in which the governance of heterogeneous electricity infrastructures is embedded.

Explaining heterogeneous urban electricity constellations through governance modalities

Before introducing governance modalities as our analytical categories, we first define governance. Mayntz [29: 122] refers to governance as "collective action in matters of public interest." Urban electricity governance consequently addresses the question of how to ensure and improve electricity provision in urban contexts. This can involve the goal of promoting the transition of electricity provision and use from one system to another to advance low-carbon electricity production or energy efficiency to address economic efficiency, social equity, and environmental protection. Central to this perspective is the conceptualization of urban infrastructural developments as emerging or planned changes of and within socio-technical systems. Mayntz [29], for example, distinguishes three key elements of these systems: (a) the underlying technological structure; (b) how provision and use are socially organized; and (c) how the technological structure and social organization are externally regulated.

Governance research has used the three most common and ideal modalities to explain how institutions shape policy outcomes, namely, hierarchical, market-based, and network governance [25]. For our case study, we add a fourth distinct modality that has been discussed in the literature but does not represent one such ideal type and has thus not been frequently used to analytically frame governance mechanisms: managerial governance [24]. To analyze and explain real-life phenomena, modalities as such broad categories must be defined context-specifically. For each, it is possible to distinguish different features which function as variables that help to subsume

all relevant processes and institutions and so sufficiently explain empirical outcomes [cf. 22: 60]. To operationalize the modalities, we categorized their features along three dimensions—institutions, actors, and policy instruments—primarily based on institutional aspects in line with the actor-centered institutionalism approach. These features are summarized in Table 1 and are briefly discussed below in the context of urban electricity systems in sub-Saharan Africa.

Hierarchical governance comprises top-down processes with fixed rules. Powerful actors, often part of the state or mandated by it, can command, control, and sanction others. Particularly, national governments influence electricity sectors, because they are essential for economic development and electoral support. Hierarchical governance usually includes mundane yet diverse bureaucratic practices [15]. However, hierarchies can also function through a ‘command mode’, whereby a “person in power can overrule existing legal rules and regulations” [30: 389]. Such interventions, for example, by presidents, are exceptional but influential [cf. 31]. Hierarchical governance is not confined to state actors; international organizations (so-called ‘development partners’) exercise significant power, too. Since African electricity sectors depend on development funding [32], development partners can impose their own rules, for instance through funding decisions. Their ability to control or sanction state actors such as governments, regulatory authorities, or utility companies (e.g., by funding withdrawal) provides them with command-like powers [33].

Market-based governance involves price formation in markets, driven by profit-oriented individual actors. To function efficiently, markets rely on decentralized actors among whom power is dispersed. In reality, however, economic, political, and physical barriers restrict market access. Particularly, the operation of large infrastructure networks represents a ‘natural monopoly’, whereby effective state intervention needs to prevent operators from abusing their positions. In African contexts, national government interests often oppose market-based modalities to become dominant in electricity sectors [34], except for electricity generation, where competition among (private) producers is increasingly common [35]. In urban contexts, market-based modalities outside of the electricity sector may play a role, including real estate speculation [36] or large industries [13] influencing electricity demand and its spatialities. Besides, electricity in sub-Saharan African cities is often supplied by private, small-scale providers who offer alternative services (e.g., generators) in largely unregulated markets outside of official monopolies for grid-based electricity provision [4]. Although the main motive of these small-scale providers is profit-making, their interests extend beyond that. Such

‘merchants’ [15] are often accountable to the communities they serve and to the—mostly local—state actors who facilitate their operations.

Network-based governance is characterized by a more horizontal decision-making process compared to hierarchical governance. Divergent interests are reconciled through negotiation to achieve compromise or consensus. Longer lasting relationships establish trust and mutual expectations between actors [25]. Although including more non-state actors through networks may diffuse power and enable diverse interests to be accommodated, network-based modalities often risk being exclusive [37]. Involvement in networks frequently depends on existing capacities and social bonds that favor the participation of powerful actors with similar interests who may shape outcomes at the expense of others. We distinguish network-based governance at two levels. *National-level policy networks* with powerful actors can shape governance by negotiating how policies and regulations are formulated and implemented. These networks encompass development partners, corporations, advocacy groups, regulatory authorities, and governments. Such composition may exclude the interests of less powerful stakeholders and the demands of local interest groups [cf. 33]. Local interests, however, can be conveyed through *local policy networks*, within which residents or communities can negotiate access to electricity services with utility companies and state actors such as the national government [11]. Local networks are often short-lived and evolve around project-oriented tasks. Although these networks have a collective intent, influential members can use them to pursue individual interests [38]. Network-based modalities also shape alternative services among neighbors and communities [10]. In such localized networks, “citizens and other non-governmental actors take the lead” [39: 344], deciding whom to involve and how to allocate resources in the absence of reliable or accessible public service provision.

We consider *managerial governance* another distinct modality to better explain the (re)production of heterogeneous urban electricity infrastructure. This modality indicates a shift away from hierarchical decision-making by governments which strictly control public sector companies such as electricity providers. By paying greater attention to predefined, outcome-based performance indicators, managerial governance provides a higher level of organizational autonomy: decision-making is dominated by utility company managers rather than elected officials. These managers flexibly set and implement rules, focusing on achieving commercial goals such as cost-efficiency. This commercialization has been criticized for lacking democratic and participatory elements and marginalizing

Table 1 Four governance modalities and their underlying features

	Hierarchical	Market-based	Network-based	Managerial
Institutional features	Mechanisms of interaction/logic of decision-making	Commercial exchange; price signals	Participatory, member-led; negotiations and informal exchange of views and interests	Authoritative/autonomous; may involve quasi-deliberations (choreographed participation)
	Rule structures	Formal and informal rules of exchange	Informal (self-defined) rules, cultural values; rules and procedures are flexible (evolving through, and shaping practices)	Formal, yet flexible rules, focused on achieving targets
Actor features	Associated actors	Public utility companies and private companies; individuals as co-providers	Users (both individual and collective, as associations), housing associations, NGOs, local bureaucrats	Civil servants, public or semi-public entities (e.g., utility companies), public-private partnerships, development partners
	Actor participation and relationships	Ideal: open participation; in reality, hindered by entry barriers (monopolies or oligopolies)	Participation only open to associated members; members decide about participation	Bureaucratic and contractual relations determined by key actors
	Key actor objectives/motivation	Profit maximization, increased market share, improvement of revenue base, safeguarding rent extraction	Improved position of participants or members (e.g., better access to services, economic or political standing, etc.)	Efficient delivery of determined outputs, minimizing reliance on external funding (autonomy)
	Power basis	Competitiveness (prices, ability to respond to demand, ability to maintain market share/position)	Shared resources, social capital, leadership; can be appropriated by powerful individuals to determine rules and procedures	Legal mandate, technical and economic expertise; managerial knowledge, economic resources
Policy tools	Commonly associated instruments	Contracts and informal commercial agreements, trading mechanisms	Written and unwritten agreements; entitlements	Price/cost and output-driven techno-managerial tools (performance measurement, targets, and benchmarks)

Source: Author synopsis based on, e.g., [15, 24, 25, 39, 42]

Table 2 Overview of the wards of our empirical studies

Income status and key challenge	Ward	Characteristics and development patterns	Population (2012)	Key function
Affordability and reliability in low-to-medium income areas	Kariakoo	Commercial center and market place; planned area undergoing vertical redevelopment	13.800	Commercial and residential
	Jangwani	Unplanned, dense settlement in a low-lying area adjacent to Kariakoo	17.600	Residential
	Kilakala	Rapidly densifying, unplanned settlement; fast growth	45.000	Residential
connectivity in peri-urban areas	Mabwepande	Unplanned area with uncoordinated and incremental growth	25.500	Residential
	Chamazi	Unplanned area with uncoordinated and incremental growth	63.700	Residential
Premium reliability in affluent residential, commercial, and industrial areas	Kisutu	Consolidated settlement with (government) offices, high rise buildings undergoing further redevelopment	8.300	Commercial and administrative center
	Mikocheni	Consolidated area with light industries and growth of premium residential complexes	32.900	Industrial and residential
	Msasani	Consolidated, affluent, and low-density residential area with commercial activities, slow growth	6.300	Residential and commercial

Source [4, 43]: (Population and Housing Census numbers, rounded to 100)

the public interest [24]. Development partners have promoted managerial modalities to reform African infrastructure sectors whose national state-led, hierarchical organization was considered inefficient [40, 41]. The consideration of managerial governance as a distinct modality is thus important to advance our understanding of how managerial ideas and practices as well as their interplay with hierarchical governance may reconfigure public sector institutions and urban infrastructural outcomes.

In our case study, we use these governance modalities to explain how institutional aspects shape heterogeneous urban electricity constellations across diverse urban settings in Dar es Salaam. Using modalities to conceptualize urban electricity governance in sub-Saharan cities creates a nuanced understanding of how urban energy transitions in such contexts do and could evolve. Established understandings of energy transitions assume the existence of a relatively stable socio-technical regime with dominant institutions that must be destabilized and reconfigured. In contrast, the modalities used here redirect our attention to the complex interactions of institutions and actor arrangements which explain the ongoing emergence and persistence of heterogeneous urban electricity constellations. As such, they build a basis to think through how purposeful attempts to promote energy transitions may evolve or be hindered.

Methods

Our study is based on a qualitative case study approach covering three neighborhood types in Dar es Salaam which reflect the city's diversity and heterogeneous user demands across settlements: low-income, peri-urban, and affluent areas. For each settlement type, data have been gathered in two, respectively, three, wards of the Dar es Salaam administrative region to accommodate nuances within each type. To this end, data were gathered between June 2018 and January 2020. At the neighborhood level, we interviewed residents and community leaders to understand local modes of coordination and observations of technical features and user practices. Interviews with residents took place in proximity to the ward and sub-ward offices, where interviews with the respective officials and community leaders were conducted. This approach cannot fully reflect the diversity within administrative wards (e.g., concerning spatial differences in network coverage), which often cover a large territory. However, it allows to analyze broader differences across neighborhood types based on *predominant* electricity challenges. Table 2 below provides an overview of the wards, where interviews and field visits for the case study were conducted.

The predominant electricity challenges related to affordability, connectivity, and reliability in the different neighborhood types have been identified through interactive 'Community of Practice' meetings with key

stakeholders from the Ministry of Energy, the electric utility company TANESCO, the regulatory authority EWURA, international development partners, urban planning officials, researchers, and NGOs. Finally, we complement gray literature, policy documents, public statements, and newspaper articles with 62 in-depth, semi-structured expert interviews with the abovementioned community leaders and key stakeholders as well as private businesses and lobby groups. Data were interpreted using qualitative content analysis. We used Mayntz' [29] components of socio-technical systems to characterize the heterogeneous electricity constellations existing in Dar es Salaam. To explain their governance, we then situated the data within our analytical framework using governance modalities as the main analytical categories and the governance features in Table 1 as underlying variables.

Results

The formal institutional structure of Tanzania's electricity sector is dominated by state actors, first and foremost the national government, headed by the Ministry of Energy which is responsible for policy-making and planning. TANESCO, a vertically integrated public utility, implements government policies and advises the resource-constrained ministry. For urban areas such as Dar es Salaam, TANESCO formally holds a monopoly to supply electricity and is thus regulated by the Energy and Water Utilities Regulatory Authority (EWURA). EWURA reports to the Ministry of Water and Irrigation and is, therefore, somewhat independent from political interference from the Ministry of Energy. Under the auspices of these state actors, electricity governance aims at universalizing and homogenizing conventional electricity grids (Interview 1).

Besides this formal bureaucratic structure, hierarchical decision-making in the sector is powerfully shaped by the political interests of Tanzania's president and the ruling party Chama Cha Mapinduzi (CCM). To illustrate, the president can appoint and dismiss top EWURA and TANESCO personnel, as happened during a dispute over electricity tariff increases in 2016 [44]. Two political goals of the administration stand out: first, maintaining cheap electricity tariffs to promote industrial manufacturing and enable state-led (rather than private sector-driven) economic development. This has implications for Dar es Salaam, where most industrial electricity users are located. Second, an 'energy access for all' agenda intends to help achieve equal living conditions [27], a goal linked to maintaining electoral support for CCM which has been in power since Tanzania's independence and is thus inseparable from the government and its institutions. The abovementioned tariffs dispute indicates the

importance of affordable access to basic services in the political process.

However, tariffs kept politically low conflict with the resource needs of grid expansion to achieve 'energy access for all'. TANESCO, the key actor responsible for delivering on both objectives, constantly requires government subsidies and has frequently been criticized for its performance, management decisions, and corporate finances [45]. Equally important is TANESCO's reliance on the funding and technical support of international development partners whose main interests are tangible outputs like progress toward the United Nations Sustainable Development Goals. These actors coordinate their actions in a network called the Energy Development Partners Group (Interview 2). They negotiate the terms of assistance with state actors like the government, EWURA, or TANESCO individually and collectively, urging for alignment with their goals and implementing proposed reforms. In its most extreme form, development partners can apply conditionalities and threaten to withdraw funding (Interview 3). In line with broader neoliberal reform agendas, development partners have long promoted private sector participation, the unbundling of TANESCO, and the introduction of managerial practices which focus on economic efficiency and cost recovery [41]. However, and similar to other sub-Saharan African contexts [e.g., 35], the creation of competitive markets has been limited to a few private actors participating in electricity generation.

The simultaneity of a strong political grip on the sector and the reliance on external resources has produced a double bind within TANESCO's management and operations. The company faces the challenge of navigating this "confused and contested policy and institutional space" [40: 3958] characterized by diverging political and funding pressures, networks of actors, and unaligned service provision logics.

The difficulty of adequately addressing this challenge is most visible in Dar es Salaam, Tanzania's largest and economically most important city, which consumes half of the country's electricity. Its dynamic growth is projected to result in a doubling of its population between 2020 and 2030 [46]. Urban growth is most visible at the urban fringes, where peri-urban sprawl, mainly driven by private individuals, prevails. It also manifests in densifying poor, unplanned neighborhoods and vertical redevelopment [26]. This urban diversity comes with highly heterogeneous electricity demands to which conventional grid services and national policies do not respond to sufficiently. These demands comprise (a) affordability in low-income settlements and sufficient reliability in middle-income areas; (b) timely connectivity in peri-urban settlements; and (c) premium reliability in affluent

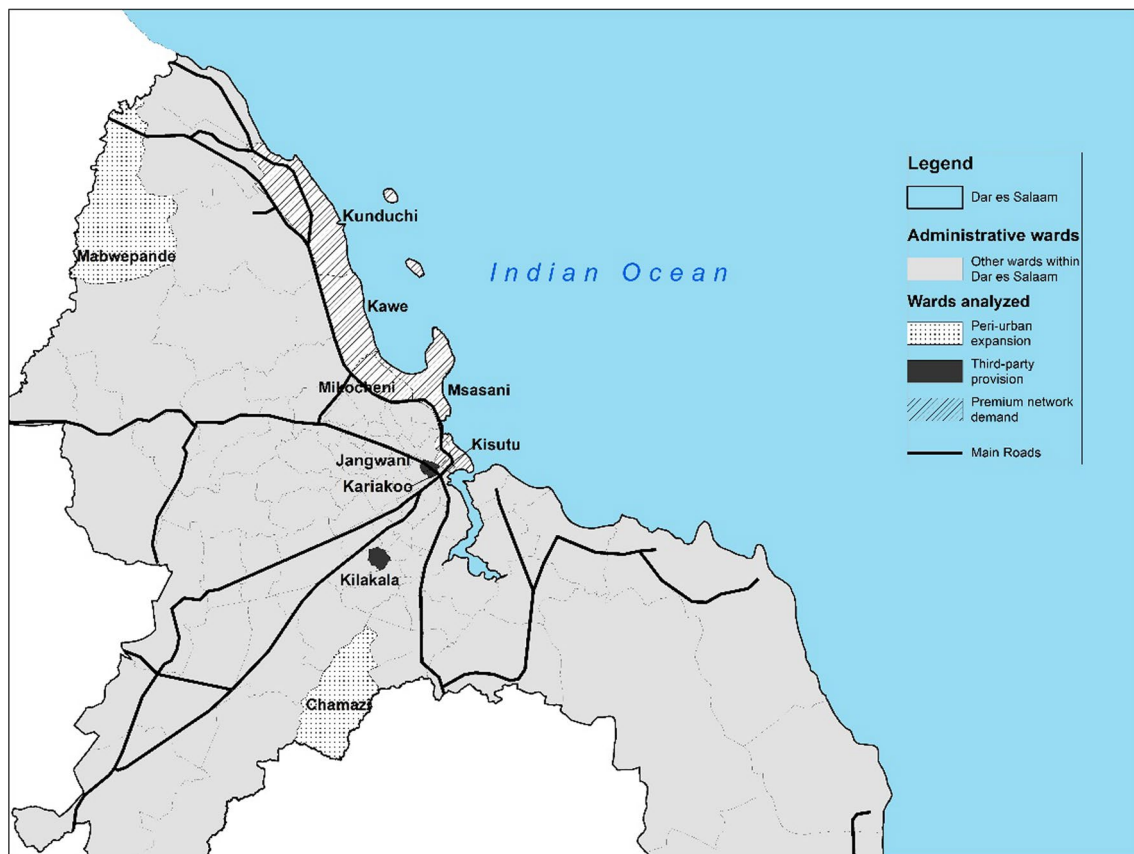


Fig. 1 Overview of predominant electricity challenges across wards in Dar es Salaam (Authors' illustration)

residential, commercial, and industrial areas. We identified these as critical challenges for urban electricity governance based on stakeholder consultations with key state representatives from EWURA, the Ministry of Energy, and municipal planning officials, the government-owned electric utility company TANESCO, NGOs, and international development partners (Interviews 1 and 4). Figure 1 shows a map of the exemplary wards¹ in which they occur.

Heterogeneous electricity constellations have emerged as coping mechanisms to address unmet electricity demands across different urban settings [4]. These constellations consist of various socio-technical channels, including individually and collectively operated off-grid systems such as generators and solar panels, legal and illegal shared grid connections provided by third parties, or the tacit prioritization of grid services in certain areas by TANESCO itself.

In the following sections, we use the three urban settings in our case study to analyze the governance of these heterogeneous electricity constellations across Dar es Salaam. We explain how institutions and processes beyond national sectoral governance contribute to how these constellations emerge and function through the lens of the four governance modalities derived from our conceptual framework. We examine, first, why diverse urban service needs are not sufficiently met by conventional grid services and, second, the numerous interests, decision-making processes, and service provision logics at play in the provision and use of different socio-technical alternatives.

Local networks and market-based modalities governing co-provision channels

TANESCO struggles to provide affordable grid connections for low-income users and sufficient reliability for middle-income users. In both cases, *third parties co-provide services* that complement conventional services through off-grid systems and alternative means to access the grid. Co-provision channels involving third parties—usually building operators and landlords—emerge in two

¹ The attribution of wards to a specific type in our analysis is based on the predominant electricity challenge in the area, despite many wards being large and internally diverse.

ways: first, meter-sharing arrangements among several households circumvent unaffordable grid connection fees for poor tenants in neighborhoods, such as Jangwani and Kilakala. They rely on their landlord as a registered customer to pass on electricity (Interview 5). However, the households' accumulated consumption exceeds the maximum allowed to benefit from a subsidized lifeline tariff (75 kWh a month per meter). Hence, they pay the residential tariff at three times the price. This phenomenon is widespread [cf. 41], with up to 40% of Dar es Salaam's households affected. Second, TANESCO cannot provide sufficiently reliable services in areas such as Kariakoo. Here, the operators of multi-story apartment buildings provide backup electricity to low- and middle-income users to cope with the grid's unreliability.

State actors neither actively promote nor discourage both channels (e.g., through regulation by the government and its regulatory authority). The key *hierarchically* set government goals, 'energy access for all' and the affordability of services, are considered to be largely achieved in Dar es Salaam (Interview 6). Indeed, most residents have electricity in their homes and a pro-poor policy supposedly allows its cross-subsidized use (Interview 7). However, a narrow focus on high connectivity rates (the percentage of households with electricity) and written policies disregard crucial elements of electricity use, such as reliability and affordability. In reality, *managerial* practices hamper the realization of these goals. First, effectively implementing the lifeline tariff requires separate accounts and hence separate metered connections for each household. However, separate connections remain unaffordable for poor tenants, because TANESCO treats meter installations as new connections subject to cost recovery principles (Interview 8). Second, TANESCO has—urged by development partners—successively reduced cross-subsidization to keep industrial tariffs competitive. Extending the lifeline tariff would reduce TANESCO's commercial viability and risk political intervention. Increasing investments in overloaded distribution grids to increase reliability provides a similar challenge: it would strain the company's resources without significantly improving its revenue base.

External pressures on TANESCO concerning these issues are low. Responsible state actors such as the ministry, EWURA, and the EWURA CCC (a formally independent state organization representing user interests) lack the necessary monitoring capacities [45]. This leaves alternative technologies, and 'behind the meter' practices pursued by non-customer users and co-providers, weakly regulated. Besides state actors' unawareness of the varied consequences of co-provision (Interview 9), they also have little reason to intervene given the formal fulfillment of goals and TANESCO's commercial situation.

Co-provision thus conceals the contradictions between hierarchical and managerial governance and the inability of conventional grids to fulfill heterogeneous user demands.

Local networks mainly govern shared-meter arrangements. User households negotiate service features among themselves or with their landlords, who often live nearby. Close landlord-tenant relationships generate responsibility for safeguarding service access, resulting in flexible rule-setting and enforcement. Landlords hold significant decision-making power over payments, appliance usage, and internal (dis-)connections. However, the flexibility and informality of provision and usage logics (terms of payment, usage restrictions, etc.) leave room for misunderstandings and landlord exploitation—which local leaders described as resulting in severe disputes (Interviews 5, 11).

Although mandated actors such as the CCC are not involved in or able to address such problems, state action remains essential for such local networks. As key state-community intermediaries, ward and sub-ward (mtaa) officials are the residents' first point of contact to address user challenges. Local officials exercise authority based on trust and local embeddedness. Despite lacking official mandates, they are politically accountable to residents and—at least the elected officials—rely on residents for re-election. Consequently, it is in these officials' own interest to facilitate negotiations with TANESCO as well as mediate conflicts, and represent residents (Interview 10).

In apartment complexes, landlords and building operators are usually corporate actors lacking similar social bonds and accountability. Market-based transactions thus govern back-up electricity co-provided through generators. However, there is no actual competition among backup providers. Rather, co-providers dominate rule-setting through an unregulated housing market such as using standardized agreements in rental contracts (Interview 11). Landlords offer apartments with or without backup power, with different service levels and varying fees. As such, their powerful position allows them to enjoy the profits of inflated electricity bills. However, excessive charges of more than 35% above TANESCO tariffs have attracted negative regulatory attention [47], which has led to more subtle approaches: landlords now factor their profit margins into unregulated housing rents.

Relying on networked governance to cope with peri-urban connectivity challenges

Another key challenge for TANESCO is expanding connectivity in low-density, peri-urban neighborhoods such as Mabwepande or Chamazi which experience rapid

sprawl driven by individual homebuilders. The patchy grid coverage here vividly illustrates the difficulty of effectively coordinating service provision and urban growth. This growth occurs largely unhindered by lagging municipal and national institutions tasked with officially governing land transactions and ownership [cf. 26]. Hence, they are complemented by informal institutions through which ward and sub-ward officials facilitate individual, market-based transactions to accommodate the demands by residents while ignoring official land-use planning designations. Although municipal planners acknowledge their inability to manage peri-urban growth, they also criticize ward and mtaa leaders' unilateral actions, the deficient coordination among local actors, and the resulting unplanned settlement patterns (Interview 12).

Despite this unplanned status, government goals require TANESCO to process connection applications and quickly expand its grid. A senior government official doubts the feasibility of such goals, describing them as a "political move" not beneficial for TANESCO (Interview 7). To fulfill its responsibilities, TANESCO informally liaises with local leaders who want satisfy residents' requests, using their knowledge to assess settlement developments and service needs. Although this approach is costly, because it involves many of the company's staff, a TANESCO engineer considers it a success as it is relatively quick and efficient (Interview 13). However, municipal planning officials excluded from the coordination argue it further complicates their efforts to align informal growth and infrastructure access (Interview 12).

Although this approach allows TANESCO to effectively track resident demands, the company's managerial practices prevent it from using this position for timely end-user connections. Meeting the initially low electricity needs from the few and scattered residents is unprofitable due to the high investment needs of grid expansion. Although connection fees are set to be cost-reflective, a TANESCO engineer confirmed that they are insufficient in bringing the grid sufficiently close to potential customers before a settlement densifies (Interview 14).² Exacerbating this problem, many potential clients cannot afford the connection fees that customers must pay once the grid is nearby. TANESCO consequently delays commercially unfeasible individual connection applications until there are enough customers.³ Once this is the case though, the company moves fast, ignoring hierarchical planning institutions. Liaising with local leaders who are "more helpful than the municipality" for accessing the

necessary land for grid expansion (Interview 14), TANESCO managers apply *practical norms* to navigate conflicting managerial interests and hierarchically set goals while justifying this practice as serving broader public interests.

Often facilitated by local state actors (e.g., ward executive officers) or privileged residents, residents collaborate in local networks to address the long waiting times for connections. They jointly try attracting TANESCO's interest, for instance by pooling finances to reduce individual connection fees. Typically, such initiatives are ephemeral, lasting only until their goals are achieved. Residents may also have the ability to initiate direct discussions with high-ranking ministry or TANESCO personnel or mobilize contacts with powerful decision-makers in national policy networks, such as by exerting pressure through parliamentary representatives. This pressure can outweigh routinized managerial practices and lead to flexible interpretations of commercial feasibility guidelines.

Self-organized alternatives also emerge from local networks. For instance, some unconnected residents use extension cords to access electricity through already connected neighbors. Due to its illegality, this practice requires trust between households as parties jointly negotiate usage characteristics and payments. TANESCO regularly disconnects these illegal users and fines the connection owner, despite not incurring commercial losses, even though a timely grid connection is unavailable. Company managers argue that penalties are essential to minimizing future illegal practices (Interview 15).

Depending on their payment capacity, other residents use individual off-grid solutions, such as solar systems, diesel generators, or non-electric alternatives. Aside from fuel subsidies, these systems are governed exclusively by ineffectively regulated markets to ensure minimum service levels. Users may, therefore, face low-quality equipment, limited electricity output, and high emissions.

Managerial governance and high-level networks to accommodate premium electricity demand

Finally, TANESCO's typical power quality and reliability do not meet the demand in industrial and commercial areas—such as Kisutu, Mikocheni, or Msasani—nor that of affluent coastal suburbs. Facing pressure from powerful actors to provide premium services, the company is required to prioritize investing in and operating distribution grids in these areas despite the statutory requirement of the grid operator to serve all customers equally. In line with the national-level state actors' (primarily the president and the Ministry of Energy) aspiration to provide homogeneous, universal grid supply, tolerated service interruptions, imposed by Tanzania's Bureau

² The proximity of potential customers is important to achieving the goal of 'access' which, however, only represents the *possibility* of being connected.

³ Only a few wealthy clients can cover the full cost of TANESCO's grid expansion.

of Standards (TBS) and monitored by EWURA, cannot be differentiated between neighborhoods or customer groups [48: 30]. However, the industrialization ambitions of the national government increase premium service demands, because cheap and readily available electricity will attract large-scale industrial and commercial investment [46].

For TANESCO, it is a challenge to maintain and upgrade distribution grids to safeguard service levels in line with the TBS standard—let alone satisfy premium demands. However, within the hierarchical procedures requiring TANESCO to report outage data to EWURA, the company is given some leeway: EWURA requires *relative* reliability improvements but abstains from strictly enforcing the TBS standard. For one thing, TANESCO's technical limitations in producing spatially disaggregated data complicate EWURA efforts to independently monitor compliance. In addition, the regulator has expressed its awareness of the multiple pressures TANESCO faces (Interview 16). However, applying such practical norms cannot be openly communicated, leading to lacking accountability and transparency.

This limited enforcement conceals spatial differences in service quality, allowing TANESCO to pursue its interests. Without efficient regulatory oversight, the company can channel scarce resources to accommodate premium user demands, avoiding further political interference by powerful actors through national policy networks. Such actors involve political or economic elites aspiring to secure high-quality service, where they live or operate businesses. These include real estate investors who speculate primarily with centrally located plots with highly reliable infrastructure provision (Interview 11). However, since spatial information about grid reliability is not publicly available, corporate investors initiate informal deliberations with TANESCO managers to learn about areas the company may prioritize. Subsequently constructed high-rise buildings require significant amounts of (premium quality) electricity and for TANESCO to allocate the respective resources. This initiates a self-reinforcing cycle of investments and premium service requirements through networked modalities and largely unregulated land markets.

TANESCO also profits from this process by securing funding from investors, thereby becoming less dependent on government subsidies. Aware of investor time pressure in a highly dynamic land market and their financial capacity, TANESCO managers negotiate favorable co-financing arrangements for distribution equipment (e.g., additional transformers). This co-financing is a small commitment compared to corporations' overall budgets, and TANESCO can use such funding to improve reliability for nearby customers. Nevertheless, ensuring

premium reliability without formalizing differentiations remains problematic. Since TANESCO cannot charge corresponding tariffs (e.g., according to service quality), it must disproportionately deploy resources.

In addition to the grid-based mechanisms described above, users run high-end backup generators to further secure high-quality service. Generators are offered by a few specialized companies in an unregulated market. Given their low running times (Interview 17), generators are expensive to operate. Their presence indicates specific users' vulnerability to interruptions and their willingness to pay for better quality service.

Discussion

Our governance modalities framework has enabled an understanding of the institutional aspects of electricity governance in the context of urban diversity and socio-technical heterogeneity in Dar es Salaam. These aspects are crucial toward understanding how heterogeneous urban electricity constellations are (re)produced as well as the implications of this (re)production for public policy interventions promoting urban energy transitions.

As a result of our study, three critical insights emerge. First, heterogeneous urban electricity constellations are shaped by institutions beyond the state-led, hierarchical modalities that govern conventional grids and the market-based modalities dominating (off-grid) alternatives [e.g., 20]. Earlier we have argued that adequate policy responses to “govern diversity” [1] require a better understanding of how heterogeneity emerges and is maintained through governance. Our study underlines that the (re)production of heterogeneous electricity constellations in Dar es Salaam can be explained through hierarchical, market-based, network-based, and managerial modalities. The interplay of these modalities reveals the complexity of established institutional logics which differ across neighborhoods. This interplay—and how actors simultaneously cope with and change it—constrains future actions toward urban energy transitions (e.g., regulatory efforts). In fact, there is not one single or dominant mechanism that guides decision-making in the electricity sector. Rather, several co-existing modalities produce conflicting rationalities and responsibilities which are difficult to navigate for actors aiming to initiate change. One key constraint is the double bind experienced by TANESCO, which has to address partially incompatible modalities. Formally, energy governance adheres to hierarchical rules (however, affected by practical norms), while managerial practices are firmly embedded within TANESCO. Resolving the conflict between hierarchical and managerial logics seems unlikely, since it originates from influential yet opposing external pressures. What could be achieved is a clearer distinction

between what marks a basic public service and which service aspects can follow commercial logics. However, this distinction would require transparent deliberation. Another element of institutional complexity that was revealed is that despite TANESCO's official monopoly in electricity distribution, actual service provision is largely organized through (unregulated) markets and local networks. These market- and network-based modalities convey the interests of numerous incumbent actors, and thus impede sustainability or public interest-driven policy interventions. Consequently, the modalities' interplay signifies a lack of: (a) clearly identifiable actors who could lead efforts promoting urban energy transitions; (b) a distinct decision-making mechanism, where such actors could coordinate these efforts; and (c) a dominant logic that guides how services should be provided in future. In sum, these issues make purposeful energy transition efforts difficult to conceive. However, this situation also means that turning away from hierarchical modalities that officially guide electricity governance would not fundamentally disrupt how urban electricity services are already organized: efforts for sustainable urban energy transitions can build on the existing breadth of modalities and actors, enabling the functioning of centralized grid services and socio-technical alternatives. This requires clearer actor assignments and resource endowments, better-defined decision-making processes, and transparently deliberated priorities among key actors.

Second, outside the realm of formal, hierarchical governance modalities, various state actors are crucial in governing heterogeneous urban electricity constellations. Actors such as EWURA, the ministry, or TANESCO interact in different policy networks and shape market-based service delivery. Their interests, capacities, and actions—but just as equally their inactivity—shape the emergence and functioning of socio-technical alternatives. Hierarchical and managerial modalities and national policy networks, through which conventional grids are governed, inadequately respond to urban service demands. National authorities such as EWURA and TANESCO lack the capacity to enforce existing regulations and acknowledge the infeasibility of strict enforcement. Similarly, the national government's inactivity in regulating off-grid alternatives and co-provision channels follows a logic: regulations in these areas would inevitably reveal that TANESCO is in fact not a monopolist and public institutions are unable to respond to heterogeneous demands. Hence, these actors silently tolerate alternative service provision, a phenomenon that resembles “a system of deregulation [that] can be thought of as a mode of regulation” [49: 83]. This inactivity can thus be explained by and serves specific interests—it neither signifies governance failure nor the withdrawal of state

actors from governance processes. Furthermore, this inactivity also conflicts with energy transitions as processes which require an active and coordinated pursuit of changing established socio-technical systems.

The role of local state officials on the ward and sub-ward level (i.e., ward executive officers and elected councilors) in facilitating TANESCO's grid expansion and alternative services emphasizes the state's importance in potentially governing urban energy transitions. Their enabling, active role within local policy networks resembles what Roll [30] called “pockets of effectiveness” with strong ties between actors, balanced powers, and mutual commitments—providing a contrast to the inactivity of national level actors discussed above. The Dar es Salaam case shows that local state actors have the potential to be crucial mediators for sustainable energy transitions in the context of heterogeneity, for instance by (1) distributing knowledge and information that can help better align interests and improve coordination among actors and (2) enabling or restricting the occurrence of specific socio-technical alternatives and their externalities. Although local officials' actions often follow user rationales very closely to maintain political support and, therefore, disrupt formal governance mechanisms, better understanding their mundane, everyday practices may “hold the potential for different infrastructural possibilities” [17: 261].

Finally, the market- and network-based modalities mainly governing socio-technical alternatives seem particularly inappropriate for achieving energy transition ambitions. They are key elements of incumbent actors' governing approaches to maintain the status quo marked by heterogeneous electricity constellations. Without actively addressing these modalities (e.g., through regulations), they seem inapt to contribute to existing state goals (i.e., universal access) as well as potential future urban energy transition goals such as redressing urban inequalities or safeguarding urban sustainability more broadly. Current co-provision channels involve a high risk of exploitation and rent-seeking, for example, by linking to unregulated housing markets that influence infrastructure access. These markets cannot ensure minimum service levels, affordable prices, or acceptable emission levels. Where users depend on local networks, this favors communities with greater resources and connections to powerful actors, while other residents resort to stand-alone systems and are exposed to high prices. In the case of premium service demands, TANESCO cannot charge higher tariffs for the favorable conditions it provides, thus perpetuating infrastructural inequalities. Sustainable energy transition efforts could benefit from carefully exploiting the willingness of affluent users to pay for premium services, which could also mobilize

funds for (better) electricity access across the city and especially in low-income communities. Beyond these local challenges, current governance modalities provoke highly unsustainable practices concerning emissions and resource efficiency (e.g., unregulated decentralized backup generators and lacking energy efficiency policies).

Conclusions

In this paper, we have investigated how urban electricity governance shapes the (re)production of heterogeneous electricity constellations in the context of Dar es Salaam. These constellations are crucial for the functioning of cities in the global South, particularly in sub-Saharan African cities, where they have been analyzed as a response to the inability of conventional grids to respond to urban diversity [1, 2]. Our study contributes to emerging debates on how heterogeneous urban infrastructures could be mobilized to promote sustainable urban energy transitions. Compared to existing studies, we provide a distinct institutionalist governance perspective that demonstrates how heterogeneous constellations are the outcome of interrelated and place-based governance modalities. Exploring four different modalities and their interplay, our paper shows that formal, hierarchical modalities are only one among several institutional mechanisms explaining the governance of conventional grids and alternative socio-technical alternatives. Hereby, adding managerial governance as a separate modality has been central to explain how heterogeneous urban and infrastructural heterogeneity emerges and persists. This understanding of how existing institutions shape heterogeneous electricity constellations provides a crucial input toward better addressing them in future [cf. 1]. By explaining existing, place-based interests, interactions, norms, and ideals, our empirical engagement with governance modalities reveals the institutional complexity that enables and constrains potential policy interventions toward urban energy transitions.

Our case study identifies three key governance issues related to heterogeneous urban electricity constellations which require particular attention, because they potentially affect future attempts to promote urban energy transitions. First, inadequately aligned service provision logics exist, both within conventional grid governance and between conventional and alternative socio-technical services. These logics simultaneously encompass contradictory political goals (e.g., grid connectivity and electoral support), economic rationales (cost recovery), and different dimensions of electricity access. Consequently, transition attempts that are directed at one of these may be inhibited by the others. Second, this is exacerbated by fragmented actor constellations that complicate city-wide interventions. The place-based interests of

actors and diverging powers further prevent coordinated efforts, because transition goals differ as well as ideas of how services should be provided to achieve these goals. Third, multiple state actors—with or without mandates—influence the (re)production of heterogeneity across different policy levels and domains. Across diverse urban settings, our study thus confirms the state's central yet complex role [cf. 17] in the (re)production of heterogeneous urban infrastructures. Notably, national-level actors' deliberate inaction and partially opposing interests between different state actors stabilize the status quo and thus significantly narrow transition pathways.

Nevertheless, “pockets of effectiveness” within state action exist and can be expanded. Urban energy transition efforts can build upon involved local government officials on the ward and sub-ward level, their inherent interest ensure service provision for the residents in their area, and their capacities as essential intermediaries and local-level ‘champions’ [50]. However, to overcome structural barriers, officials should be given mandates and sufficient resources to perform tasks they already try to address. This expanded role must be accompanied by mechanisms to ensure accountability: besides their effective actions, local officials are also involved in power struggles and face diverging interests which may, in the worst case, lead to corrupt practices that must be prevented. National institutions, however, also need to be strengthened: formal regulations and customer protection mechanisms must be better enforced, and the organizations responsible require more capacity and local embeddedness. Moreover, urban electricity governance modalities should be rethought more broadly. Since market-based modalities already significantly shape electricity services, strict adherence to the ideal of universal grids does not seem exceptionally sensible. However, dedicated tools such as differentiated tariffs would challenge the deeply rooted logic of electricity as a public good. One approach could be to separate the service features that should be provided to all citizens equally and to investigate how differentiated features can follow market-based logic more equitably, without underestimating the impact such governance interventions can have on solidarity and social inclusion [5].

The governance modalities framework presented here opens avenues for future research. One aspect concerns the complex and ambivalent role of various state actors in shaping network- and market-based governance, which should be investigated further: socio-technical alternatives are often understood as operating in a regulatory vacuum. Yet, our study has demonstrated the importance of understanding the underlying conditions of why unregulated mechanisms prevail (i.e., various state actors' interests). More in-depth studies are needed to

understand whether this represents tacit attempts of deregulation [cf. 49]. A second aspect concerns testing this modalities-based framework elsewhere to understand how modalities and their interplay affect infrastructural outcomes differently in contexts with more market-led approaches and, therefore, less institutional ambiguity than in the case studied here [e.g., 21, 51]. In addition, in contexts where socio-technical alternatives have already been integrated into the formal infrastructure governance [cf. 14], our governance modalities framework—with managerial governance as a distinct modality—could help to understand how this integration shapes urban energy transitions.

Appendix: Referenced Interviews

1. Community of Practice Workshop. 22.01.2020.
2. Coordinator, EDPG. 27.07.2019.
3. Former manager, TANESCO. 27.06.2019.
4. Third Community of Practice Meeting. 22.07.2019.
5. Resident, Kilakala. 24.11.2018.
6. Urban planner, DSM City Council. 21.08.2019.
7. Senior executive, Ministry of Energy. 08.08.2019.
8. Manager, TANESCO regional office. 18.12.2018.
9. EWURA CCC. 14.12.2018.
10. Councilor, Jangwani ward. 11.07.2019.
11. Manager, private construction company. 30.07.2019.
12. Municipal planner, Kinondoni district. 20.08.2019.
13. Distribution planner, TANESCO. 14.08.2019.
14. Distribution engineer, TANESCO. 11.12.2018.
15. Manager Revenue Protection, TANESCO. 12.12.2018.
16. Manager, EWURA. 21.12.2019.
17. Manager, private backup company. 05.07.2018.

Abbreviations

CCM	Chama Cha Mapinduzi (Party of the Revolution)
EWURA	Energy and Water Utilities Regulatory Authority
EWURA CCC	Energy and Water Utilities Regulatory Authority Consumer Consultative Council
kWh	Kilowatt hour
TANESCO	Tanzania Electric Supply Company Limited
TBS	Tanzania Bureau of Standards

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Author contributions

MK contributed to the collection and analysis of the data and the drafting of the initial manuscript. All authors contributed to the design, conceptual framing, revision, and finalization of the article. All authors read and approved the submitted manuscript.

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Availability of data and materials

All available data generated or analyzed during this study are included in this article. Beyond that, the data sets generated and/or analyzed during the current study are not publicly available due confidentiality agreements with participants. Data may be made available from the corresponding author on reasonable request and with the agreement of the respective participants.

Declarations

Ethics approval and consent to participate

Consent to participate was obtained from interview participants and 'Community of Practice' meeting members. Compliance with relevant research ethics procedures was assured.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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